A defensible way to estimate setback distances using Trench®3.0's viral die-off method

Background

How close can an on-site wastewater system be to a sensitive feature like a swimming pool, property boundary, house, or farm dam so that subsurface effluent seepages have acceptably low adverse effects? (In other words, what is the minimum allowable separation distance, or "setback distance"?) It is very important to recognise that the setback distance applies to subsurface seepages from normally operating systems, not overland flow from failing systems, and that the required setback ought to vary depending on whether the wastewater disposal area is upgradient, downgradient or cross-gradient from it. Setback distances also have nothing to do with the volume of wastewater being disposed of.

In Australia, Australian/New Zealand Standard 1547:2012 *On-site domestic wastewater management* offers guidance for setback distances in Appendix R, and permits flexibility depending on local conditions. Many shire Councils throughout Australia do the same. Mostly, these distances have little or no scientific basis.

The viral die-off method

Trench®3.0 has long offered a viral die-off approach[1] for estimating setbacks (Figure 1). Its scientific basis is that the rate of viral die-off in saturated soil is strongly temperature-dependent. Viruses are also more resistant to natural die-off than bacteria, so if viral numbers in an effluent in soil are acceptably low, bacterial numbers are also. The method has two steps:

> Step 1
> How much time is needed for viruses in an effluent to naturally die off to acceptably low levels? [To estimate this "Approx. viral die-off period", we need effluent quality and temperature]
>
> and
>
> Step 2
> How far has the effluent seeped laterally downgradient or crossgradient in that time? [To estimate this "Wastewater travel distance in die-off period", we need the slope of the site, soil permeability and soil porosity]

To the answer to Step 2, we usually add a factor of safety and call it the "minimum setback distance required". The example in Figure 1 is the Trench®3.0 module relating to two-layered soil with "impermeable" subsoil, with (mathematically) acceptable inputs for the five needed site factors, a calculated wastewater travel distance of 2m and (as a conservative measure) an adopted setback distance of 4m.

Constraints and issues with the method

The die-off method requires saturated subsurface flow. It cannot be used in karstic or very cold terrains, and ought not to be used for unstructured, very low permeability soils because the low permeability input sometimes produces very small setback distances.

An issue for assessors and regulators alike is that most of the time, the numbers we enter for effluent quality, temperature and soil properties are estimates at best, and often guesses, and for any given site we can easily generate any setback distance by changing the inputs. It's true

[1] See Cromer, W. C. (1999). *Trench™3.0: An AIEH computer software application for managing on-site wastewater disposal*. Environmental Health Review, May 1999, pp 23-25, Cromer, W. C. (1999). Trench™3.0: A computer application for site assessment and system sizing, in Patterson, R. A. (Ed.) *On-site '99 – Proceedings of the On-Site '99 Conference: Making on-site wastewater systems work*. Univ. of New England, Armidale, 13-15 Jul 1999, pp 85-88, and Cromer, W. C., Gardner, E. A. and Beavers, P. D. (2001). An Improved Viral Die-off Method for Estimating Setback Distances, in Patterson, R. A. (Ed.) *On-site '10 – Proceedings of the On-Site '01 Conference: Advancing on-site wastewater systems*. Univ. of New England, Armidale, 25-27 Sept. 2001, pp 105-112

that Trench®3.0 offers guidance on, and suggests reasonable values for, all the inputs, but I'm sure that in more than a few cases unscrupulous assessors have yielded to temptation or client pressure and back-calculated the setback distance to fit the site. A regulator might be suspicious, but without access to the actual Trench®3.0 file he has no way of checking the assessor's inputs.

Misuse of the viral die-off method in this way might lead to a lack of trust in it.

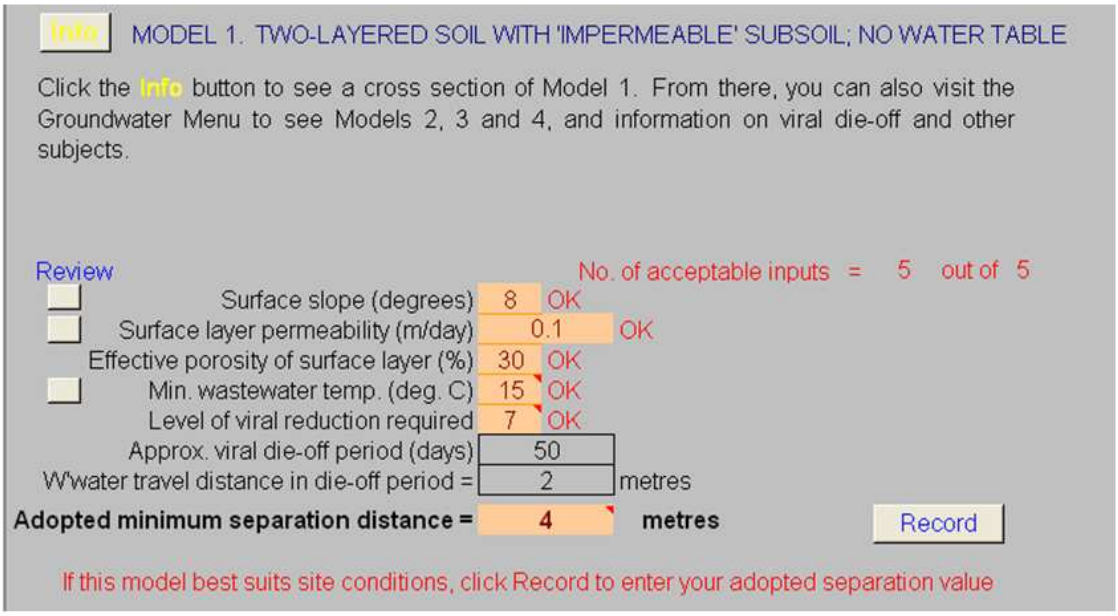

Figure 1. **The Trench®3.0 module for estimating setback distances for two layered soils. There are several other modules for different site conditions.**

A better approach for assessors

A better way for assessors to use the viral die-off method is to recognise that a single setback distance is almost certainly indefensible and too prescriptive. It would be preferable to select a range of values for some of the inputs, and from it calculate a range of corresponding setback distances. By inspection, some of the distances that arise from unlikely combinations of inputs can be eliminated, and a reasonable (and more defensible) smaller range of setbacks can be chosen – and perhaps presented in a Table.

What follows are some thoughts on input ranges, and an example.

Thoughts on input values

Review the input factors and be alert to their possible ranges.

- The surface slope of the site is usually the least uncertain of our inputs, so we can use its actual value – measured on the ground, or estimated from contour maps. If the slope angle changes (as it often does), use an average value for the distance between the disposal area and the sensitive feature.

- For primary treated effluent, use a "Level of viral reduction required" of 7 or 8, and for secondary treated effluent, a value of 3. Once selected, the value does not change.

- For soil permeability, use either a measured permeability or (better) the geometric mean of several permeabilities measured on the site. Once selected, the value does not change. If no actual measurements are available, use a range of permeabilities appropriate for the soil type. Table 1 offers guidance, using data extracted without alteration from Table L1 of AS/NZS1547:2012.

- For "effective porosity" of the soil, use a reasonable number between (say) 20% and

35%. Once selected, the value does not change.

- "Minimum wastewater temperature" is the temperature of the wastewater in the soil. It varies seasonally, so reasonable inputs would be within the range of the minimum to maximum mean monthly air temperatures for the area (in Australia, from Bureau of Meteorology records).

Table 1. Soil category, texture, structure and permeability according to Australian/New Zealand Standard 1547:2012

Soil category	Soil texture	Structure	Indicative permeability (m/day)
1	Gravels and sands	Structureless (massive)	>3.0
2	Sandy loams	Weakly structured	>3.0
		Massive	1.4 – 3.0
3	Loams	High/moderate structure	1.5 – 3.0
		Weakly structured or massive	0.5 – 1.5
4	Clay loams	High/moderate structure	0.5 – 1.5
		Weakly structured	0.12 – 0.5
		Massive	0.06 – 0.12
5	Light clays	Strongly structured	0.12 – 0.5
		Moderately structured	0.06 – 0.12
		Weakly structured or massive	<0.06
6	Medium to heavy clays	Strongly structured	0.06 – 0.5
		Moderately structured	<0.06
		Weakly structured or massive	<0.06

An example

Background

Recently I was asked by a Queensland local government authority for advice about setback distances from a watercourse for an on-site domestic wastewater system. A site assessor engaged by the property owner had recommended a minimum setback distance of 5m. The Queensland Plumbing and Wastewater Code (2011) required a 50m minimum setback, but permitted an "Alternative Solution". As it stood, the wastewater installation could not proceed, but the authority would accept my opinion as to whether the 50m limit could be reduced.

For this specific site, I noted from the assessor's report that:

- the area proposed for disposal of primary effluent was on a 10^0 slope,
- soils are Category 5 silty clay (Table 1) with the assessor's estimated permeability of 0.04m/day, and
- the distance between the disposal area and the downgradient watercourse was about 28m.

My approach

For this site, I reasonably assumed that slope angle, soil porosity and wastewater quality did not change. Soil permeability was a constant too, but its value was uncertain and I was reluctant to accept the assessor's estimate unsupported by on-site permeability testing. Subsurface wastewater temperature varies seasonally and rarely falls as low as the lowest mean monthly air temperature.

Accordingly, I calculated the viral-die-off (ie setback) distance for a range of soil permeabilities and range of subsurface wastewater temperatures. The range of permeabilities I chose encompassed the <0.06 – 0.5m/day range for Category 5 soils in Table 1. The range of temperatures I selected included the minimum to maximum mean monthly temperatures for the nearest meteorological station (from the Australian Bureau of Meteorology records).

In Table 2, I shaded grey all setback distances less than about 2m as unreasonably low, and shaded yellow all setback distances more than about 20m as unreasonably high. (This is a conservative approach given the distance available is stated by the assessor to be 28m.) The remaining "acceptable" setback distances are combinations of a range of reasonable soil permeabilities and subsurface wastewater temperatures. Note that:

- The setback distance decreases as temperature increases, so choosing a range of setbacks (eg 3 – 14m) for the lowest temperature (10^0) would be conservative (ie it would cater for winter conditions). It corresponds to a soil permeability range of 0.02 – 0.1m/day, which would seem reasonable.

- We do not have to choose a specific setback distance (which changes seasonally anyway). Instead, for the site in question, all the unshaded calculated setbacks in Table 2 are less than the available distance of 28m, so we have a reasonably acceptable alternative solution to the 50m minimum requirement.

My recommendation to the regulatory authority was that the wastewater system could be installed at the location initially proposed.

Table 2. Estimated setback distances for a range of soil permeabilities and wastewater temperatures for the site

	Est. setback distance (m; lower side of disposal area to higher side of sensitive downgradient feature)					
	Min wastewater temperature (degrees)					
Surface layer permeability (m/day)	10	12	14	16	18	20
0.01	1	1	0	0	0	0
0.02	3	1	1	1	0	0
0.04	6	2	2	1	1	1
0.06	9	4	2	2	1	1
0.08	11	5	3	2	2	2
0.1	14	6	4	3	2	2
0.2	28	12	8	6	5	4
0.3	43	19	12	9	7	6
0.4	57	25	16	12	9	8
0.5	71	31	20	15	12	10

Assumptions

10	slope angle (degrees; constant)
<0.06 – 0.15	Surface layer permeability (m/day; Category 5 soil; variable: ref: AS/NZS1547:2012 Table L1)
30	Effective porosity (%; constant)
8	Level of viral reduction required (primary treated effluent; constant)
10 – 28	Min wastewater temperature (degrees; variable; range from Southport station 040190; ref http://www.bom.gov.au/climate/averages/tables/cw_040190.shtml)